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MOBILE EMERGENCY TRIAGE: LESSONS FROM A CLINICAL TRIAL

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ABSTRACT

The Mobile Emergency Triage system is an m-health decision support system that assists hospital Emergency Department physicians in triaging various acute pain presentations at the point of care. The system is designed following the extended client-server architecture, suited for weak-connectivity conditions. The server interacts with the hospital information system to exchange necessary information, and the client, running on a handheld computer, allows data entry and provides triage support. The support function, consulting decision rules stored in the knowledge base, runs solely on the client side, thus it can be invoked anytime and anywhere. The system recently underwent a successful clinical trial.

Keywords: clinical decision support systems, emergency triage, m-health, clinical trial, handheld computers

INTRODUCTION

Patients seek care for a variety of problems in the Emergency Department (ED) of a hospital. Often, these problems are undifferentiated (not yet diagnosed) and vary in severity or acuity. ED clinicians must triage these patients so that those with serious, acute problems receive priority over those with more minor or chronic issues. They must ultimately decide which patients require specialized investigations, treatments or consultations with other medical specialists.

The first step in this triage process, prioritization, is conducted upon patient's arrival. The triage nurse determines on a priority scale how urgently a patient should be seen by the physician. For example, the Canadian Triage Acuity Scale (CTAS) [2] uses a five-level scale to differentiate patients; patients in CTAS 1 require immediate physician assessment, while those in CTAS 5 are ideally seen within 2 hours.

The physician conducts the second step of triage, medical assessment and disposition. On the basis of the patient's medical history, physical examination, and basic investigations the physician must decide how to proceed with the patient. The following disposition outcomes are usually considered:

- Discharge – discharge and possible follow-up by the family doctor,
- Observation – further observation and investigation, either in the ED or as an inpatient,

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- Consult – consult of a specialist from a specific clinical area (e.g., surgeon in case of abdominal pain or orthopedist for hip pain).

We would like to stress that triage is not synonymous with diagnosis. The latter answers the question what caused the patient's problem, while the former addresses how to manage the problem in a short term. Thus, on one hand, triage seems to be easier, as outcomes are limited to only a few possibilities (as described above), but on the other hand, it is more difficult, because much less data are available at this point of the patient management process.

A clinical decision support system (CDSS) is "any program designed to help health-care professionals make clinical decisions" [10]. This very general definition covers several categories of systems, including systems for managing patients' information (called also electronic patient record systems – EPRS [12]), systems for monitoring and alerting about abnormal patient's conditions, and systems for providing patient-specific advice based on clinical data. The recent concept of m-health [3], understood as proving required data and support in a ubiquitous manner [1], allows developing CDSS that are portable and available at the point of care. Because of these advantages, mobile solutions are becoming widely accepted in clinical settings. The majority of currently available m-health systems are drug databases and patient tracking systems [4]. There are few mobile CDSS offering patient-specific advice (for example [15]), however, most of them are implemented as simple medical calculators or scoring procedures [4].

Responding to the challenge of supporting ED triage as part of the efforts to improve healthcare process and patient outcomes, we developed the Mobile Emergency Triage (MET) system to facilitate the medical assessment and disposition stage (for simplicity in the text hereafter we use the term "triage" in reference to this stage) for various presentations of acute pain. When designing the system, we combined the concept of m-health with knowledge-based decision support. The MET system runs on mobile devices and uses knowledge presented in terms of decision rules. The system contains clinical modules for triaging abdominal pain [8] and scrotal pain. The module for hip pain will be completed soon. The system and the abdominal pain clinical module were successfully tested at the Children's Hospital of Eastern Ontario (CHEO).

The paper is organized as follows. In the next section, we describe the design of the MET system. Then we discuss the clinical trial – its objectives, organization and results. Finally, we conclude with the lessons learned from this experience.

MET SYSTEM

MET follows the extended client-server architecture, suited for weak-connectivity conditions, characterized by unstable connections between a client and a server [5]. In this architecture, the extended client (also called a *thick* client) performs selected functions of the server if no connection is available. In MET, the client, running on a handheld computer, stores clinical data collected during examination and provides the triage support function. Therefore it can be used anytime and anywhere, directly at the point of care.

The main component on the MET client is the shell that is responsible for retrieving appropriate clinical modules for specific presentations of pain, customizing the user interface, and executing the modules. Each module consists of a data model that supplies specifications for clinical

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attributes, and a decision model that is composed of decision rules. The decision rules are induced from data describing past and verified experience (i.e., patients' records with verified triage decisions) using knowledge discovery techniques based on rough set theory [14] – our earlier experience [7] confirms the usefulness of this approach for creating clinical decision models. The idea of modularity comes from research on knowledge-based DSS with domain models separated from generic solvers [9]. It expands the flexibility and extendibility of the system, as it allows the modules to be added or updated without modifying the system core components (e.g., the shell).

The ED physicians work under pressure and time constrains, thus the user interface of a CDSS should be simple and easy to use with limited manual data entry and it should fit the actual workflow [6]. The interface of the MET client offers efficient navigation and access to functions reflecting all basic ED triage activities (see Figure 1 and 2). It also streamlines data entry by adapting to the type of data being entered (see Figure 3).

Figure 1. Access to basic functions

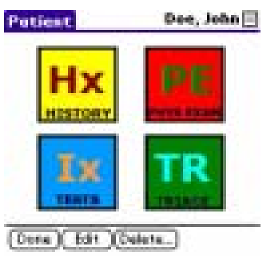
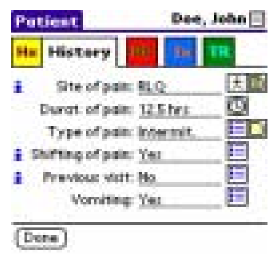


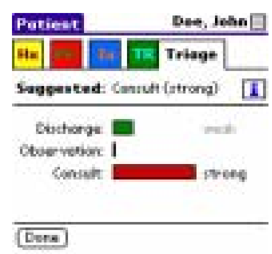
Figure 2. Navigation between functions



Uncertainty is inherent for clinical reasoning, therefore, when the system presents the triage recommendation, it shows all possible outcomes with their strengths (see Figure 4) and lets the user make the final decision. Thus, MET works not as an oracle that replaces the physician, but only as a helper [12].

Figure 3. Data entry with a body pictogram

Figure 4. Results of the triage suggestion



The MET server fully integrates with the EPRS. The server receives data collected during registration and sends back observation reports with values collected during examination. Such integration saves the physicians from the mundane task of entering demographic information and offers the possibility of using MET as an electronic extension of the paper chart. Integration with the EPRS is one of key issues for successful introduction of CDSS in a clinical practice [12] [13]. MET fully satisfies this requirement.

The MET server communicates with the EPRS using the HL7 protocol [11]. HL7 is a standard for exchanging information between medical applications that allows one to use various network protocols (e.g., TCP/IP or FTP) and to integrate diversified systems. The server also synchronizes with the clients using wireless (Wi-Fi or Bluetooth) or wired (through a cradle) connections.

CLINICAL TRIAL

Clinical trial of MET with the abdominal pain module took place at CHEO in Ottawa, Canada. A general purpose of the trial was to assess the system's performance in prospective evaluation and obtain preliminary results for the fit to the ED workflow. In order to eliminate any influence the non-validated MET recommendation would have on the physician's provision of care, the triage recommendations given by the system were blinded from the physicians. Both triage decisions (MET recommendation and the prediction of the attending ED physician) were reviewed later to calculate and analyze triage accuracy.

The MET system had to be further expanded with the management tools to satisfy operational requirements of a trial. After the patient was registered and prioritized, his/her eligibility to be enrolled in the trial was checked against a set of inclusion/exclusion criteria. If verification was positive, the patient was asked for consent to participate in the trial (consent was requested from the child's guardian). After obtaining consent, the patient was ultimately included in the study. For enrolled patients the physicians used MET to collect clinical data and to record their own predictions. In all cases, documentation of the patient's visit was also completed on the paper ED chart. The follow-up and chart audit were conducted around two weeks after the patient's visit in the ED to determine the patient's final diagnosis. The final diagnosis established during the follow-up determined the gold standard triage recommendation for calculating and comparing the accuracy of the ED physicians and MET.

The trial started at CHEO in July 2003, and continued until February 2004. During that time 2255 patients with abdominal pain visited the ED, with 1098 eligible to participate. 632 of them were approached to participate and only 38 refused consent. Finally, 574 patients were verified during the follow-up. Patients and parents did not have problems participating in the trial, as the use of MET did not introduced additional examinations or invasive tests, and did not lengthen their time spent in the ED.

Over 100 members of the CHEO ED staff (physicians and residents) used the MET system. This group had diverse prior experience with handheld computers, ranging from a complete novice to an advanced user comfortable with medical applications. All users participated in short orientation sessions and were able to operate the MET client without any difficulties.

The overall triage accuracy of the MET system during the trial was slightly lower, though not statistically different, than the accuracy of ED physicians – 65.4% vs. 70.2%. For patients who could be discharged and who required consult (discharge and consult categories) the accuracy of MET was the same as the accuracy of physicians – 72.7% vs. 71.3% and 70.8% vs. 70.8% respectively. However, MET performed significantly lower than physicians for patients needing to be observed (observation category) – 19.7% vs. 63.9%. This situation might be attributed to the heterogeneous nature of presentations in this category, as it includes patients with a wide variety of clinical conditions. Though some may question the utility of a tool with only 65% accuracy, we maintain that the performance of the MET system is satisfactory, considering that it mirrors that of experienced physicians, and considering the fact that the system is to be used as a helper that assists the physician in triaging the patient. Our assessment of the system's accuracy only considered the recommendation with the highest strength against the gold standard triage recommendation. Physicians using the tool would receive a quantification of strength for each of the three recommendations, and this would allow them to evaluate all three recommendations.

CONCLUSIONS

We designed and developed MET – an m-health system for supporting ED triage of various types of acute presentations. MET works in weak-connectivity conditions and provides the support function directly at the point of care. Moreover, it integrates with the EPRS, so it can be used as an electronic extension of the paper patient chart.

We learned two important lessons from the clinical trial of the MET system:

- The MET system was accepted by the ED staff as it introduced no disruptions or obstacles to the regular clinical workflow, and it did not increase length of stay in the ED.
- The triage performance of the system was comparable to ED staff, and confirmed the potential benefit of using the rule-based decision model and knowledge discovery techniques to capture clinical acumen.

As a next stage of our research, we plan to conduct a multi-centre clinical trial, where the recommendations generated by MET would be presented to physicians. This would allow us to study the influence of MET support on decisions made by physicians and to verify the usefulness of the clinical system working as an assistant to the patient management process.

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